MOBILE TRACK SURVEY APPARATUS FOR DETERMINING GRADE VARIATIONS

Inventors: Franz Plasser, Vienna; Franz Eglseer, Ohlsdorf, both of Austria

Assignee: Franz Plasser Bahnbaumaschinen Industriegesellschaft m.b.H., Vienna, Austria

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FOREIGN PATENTS OR APPLICATIONS
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Primary Examiner—Louis R. Prince
Assistant Examiner—Dennis A. Dearing
Attorney—Kurt Kelman

ABSTRACT
A mobile chassis runs on a load-carrying running gear and carries a track sensing element which is mounted on the chassis for free vertical movement in respect thereto to sense the vertical position of the track it engages. A pair of bell crank levers are pivotally mounted on the chassis, with one arm of the levers connected respectively to the running gear and the sensing element while the other arm of the levers is connected to an electric measuring signal generator and transmitter which generates an electric measuring signal proportional to any pivotal movement of the bell crank levers.

10 Claims, 9 Drawing Figures
MOBILE TRACK SURVEY APPARATUS FOR DETERMINING GRADE VARIATIONS

The present invention relates to improvements in mobile track survey apparatus designed to determine variations in the vertical position of the track, i.e., the condition of the track as to bumpiness, for instance at rail joints.

Apparatus for determining the geometric position, including the grade, of a track is known. In such apparatus, it has been proposed to exclude the disadvantageous influence of vibrations of the resiliently mounted chassis on the accuracy of the measurements by associating a measuring signal generator with each axle of a three-axle running gear. The signal generators were so connected that the two outer axles constituted a reference or datum, with the center axle serving as the measuring element whose movement in respect of the outer axles produced the measuring signal. However, such an arrangement is complex and expensive, particularly because of the need for a plurality of signal generators.

It is the primary object of this invention to overcome these and other disadvantages and to provide a simple and accurate arrangement for determining variations in the vertical position of the track with a single measuring signal generator per track rail.

This and other objects are accomplished in an apparatus whose chassis is mounted for mobility on the track rails for movement in the direction of elongation of the track. A load-carrying running gear resiliently supports the chassis on the track, and a sensing element engaged with the track is mounted on the chassis for free vertical movement in respect thereto whereby the vertical movement of the sensing element corresponds to the vertical position of the track it engages and thus surveys this position. In accordance with the invention, a pair of bell crank levers are mounted on the chassis between the running gear and the sensing element for pivotal movement in a vertical plane extending in the track elongation direction. Each of the bell crank levers has two arms and the ratio of the lever arms is the same for both levers. One arm of one bell crank lever is connected to the running gear and one arm of the other bell crank lever is connected to the sensing element. An electric measuring signal generator and transmitter is mounted between, and is connected to, the other arms of the bell crank levers for generating and transmitting an electric measuring signal proportional to any pivotal movement of the bell crank levers in their plane. An indicator, which may include a signal recorder and/or a control for operating track lifting tools, is connected to the signal generator and transmitter for indicating the measuring signal.

There is no relative movement between the bell crank levers due to vibrations of the chassis, i.e., when the chassis bounces on the resilient support of the running gear during forward motion of the apparatus, so that the vibrations will produce no measuring signal and will not influence the grade measurements. Measuring signals will be produced only in response to relative pivotal movement of the bell crank levers in respect to each other.

Furthermore, this arrangement according to the present invention has the advantage of measuring not only the vertical track position but also the general track condition, i.e., elastic deformations or rail joint depressions under loads. This is made possible because the vertical position of each rail point, for instance at a rail joint, is measured twice, the load-carrying running gear sensing the vertical position of the track as well as elastic deformations of the track rail under load while the load-free sensing element subsequently senses only the vertical position of the track rail. The difference between these two measurements gives the track condition, i.e., the deformation of the track rails under the load of a passing railroad car to which the track survey car used in this invention is equivalent. This makes it possible to determine what track maintenance work needs to be performed, i.e., tamping of the ballast, correcting the vertical track position, etc.

According to one feature of this invention, a pair of pivots mount the bell crank levers on the chassis for pivoting about respective pivotal axes extending transversely to the track, and the pivots are vertically spaced from each other in a vertical plane defined by the pivotal axes. To reduce the height of the arrangement, which is mounted in the relatively narrow space underneath the chassis, the arms of the bell crank levers are preferably of different lengths, and a shorter arm thereof is the one connected to the electric measuring signal generator and transmitter. The arms of the bell crank lever connected to the running gear may be shorter than the corresponding arms of the bell crank lever connected to the sensing element, and the latter may be a substantially load-free running gear having flanged wheels engaging the track rails.

While the electric measuring signal generator and transmitter may comprise an inductance and electric measuring bridge, with a housing being connected to one lever and the armature movable within the housing connected to the other lever, a particularly useful and simple signal generator will be provided if the two levers are interconnected by a flexible rod which is flexed in response to the relative movement of the levers to cause a strain to be set up therein, and a resistance strain gage means is mounted on the flexible rod for measuring the strain in the rod and generating an electric measuring signal proportional to the relative movement of the bell crank levers which causes the flexing of the rod and the resultant strain thereon. Such an arrangement is more fully described and claimed in our copending application Ser. No. 155,861, filed concurrently and entitled "Mobile Track Survey Apparatus for Determining a Track Parameter."

The chassis may be that of a track survey car or that of a track leveling machine, in which latter case the measuring signals are preferably transmitted to the automatic controls of the track lifting mechanism.

The above and other objects, advantages and features of the invention will be more fully understood by reference to the following detailed description of some now preferred embodiment thereof, taken in conjunction with the accompanying drawing wherein

FIG. 1 is a side view of a track surveying car incorporating the instrumentation of this invention;

FIG. 2 is a schematic perspective view of one embodiment of the present invention;

FIG. 3 is a side view, on an enlarged scale, of this embodiment, partly in section;

FIG. 4 is a front view of the embodiment of FIG. 3, along line IV—IV thereof;

FIG. 5 is a circuit diagram of the measuring signal generator and transmitter, with a signal indicator and recorder;
FIG. 6 is a side view similar to that of FIG. 3 of another embodiment;

FIGS. 7 and 8 show details of the latter embodiment, on an enlarged scale, FIG. 7 being a section along line VII-VII of FIG. 8 and FIG. 8 being a front view in the direction of arrow VIII of FIG. 7; and

FIG. 9 is a circuit diagram of another measuring signal generator and transmitter, with signal indicator and recorder.

Referring now to the drawing, wherein like reference numerals designate like parts operating in a like manner in all figures, FIG. 1 shows a track survey car having a chassis 3 and a body 4. The body is mounted resiliently on running gears 2, 2' whose wheels run on track rails 1, 1 so that the track survey car is mounted for mobility in the direction of track elongation. In the illustrated embodiment, the car is self-propelled, a drive motor 5 being connected to the axle of running gear 2 for moving the car along the track in a working direction (which is to the left in this figure). Measuring gear units 6, 6' and 6" are mounted on the chassis 3 and underneath it, the measuring gear unit 6' being arranged intermediate and substantially centrally between the running gears 2, 2' while measuring gear units 6 and 6" are arranged in the respective end regions of the track survey car adjacent the running gears.

Each measuring gear unit comprises two lateral rail position sensing elements constituted by axes 9a, 9b having flanged wheels engaging the respective track rails, and is mounted underneath the chassis by pivotal rods 7 one of whose ends is pivoted to the underside of chassis 3. Obliquely outwardly directed hydraulic motors 8 connect respective axes of each measuring gear unit to the chassis so that each gear may be lifted off the track rails when not in use. Due to their outward bias, the hydraulic motors simultaneously serve to press the flanged wheels of the axes against a respective rail.

The ordinates, i.e., the lateral alignment of the track rails, are measured by all three measuring gears 6, 6', 6", in a manner particularly described and claimed in application Ser. No. 155,861 filed concurrently herewith and entitled "Mobile Track Survey Apparatus" of which the joint inventor Josef Theurer is also a joint inventor. The car also carries apparatus 14 for determining variations in the vertical position of the track in accordance with the present invention, the measuring signals from this apparatus being transmitted to signal indicator 12 and/or signal recorder 13 and, if desired, computers 17, all mounted on the car.

FIGS. 2 and 3 illustrate one embodiment of the apparatus 14. FIG. 2 also shows the central measuring gear unit 6' and one of the end measuring gear units 6" for determining the lateral alignment of the track, the latter unit being herein as a sensing element which is load-free and mounted for free vertical movement in respect of chassis 3. A pair of bell crank levers 14' and 21 are mounted on the chassis between running gear 2' and the sensing element 6" for pivotal movement in a vertical plane extending in the track elongation direction. A pair of pivots 18 and 22 mount the respective levers on the chassis 3 for pivoting about respective pivotal axes extending transversely to the track. The pivots are vertically spaced from each other in a vertical plane defined by the pivotal axes.

The ratio of the lever arms is the same for both levers, the arms of the bell crank lever 21 being shorter than the corresponding arms of lever 14'. One arm of the lever 14' is connected to axle 9a of sensing element 6' while one arm of lever 21 is connected to the axle of running gear 2', a connecting rod 23 being interposed between the one arm of lever 21 and the running gear axle in the illustrated embodiment. The other and shorter arms of the bell crank levers are connected to an electric measuring signal generator and transmitter which, in the embodiment of FIGS. 2 and 3, is an inductance bridge, the short arm of lever 14' being connected to the housing 19 of the bridge while the short arm of lever 21 is connected to the armature 20 of the bridge, the armature being movable in the housing to change the inductance in response to the relative movement of the two levers in respect of each other.

Since, as fully shown in FIG. 3, the ratio of the lengths of the lever arms is the same for both bell crank levers so that relative movement between the chassis 3 and the resiliently mounted axle of running gear 2' as well as the unit 6" is completely balanced and produces no movement between armature 20 and housing 19 of the inductance bridge. Since the vertically extending arms connected to the inductance bridge are short, the entire height of the mechanism is minimal.

As the apparatus moves on the track to the left (as seen in the drawing), the running gear 2' first moves over a bumpy track point, causing the axle of the running gear to move vertically with the chassis it supports in respect of sensing element 6". This relative movement is translated into a corresponding pivotal movement of the bell crank levers and a proportional gliding movement of armature 20 in respect of housing 19, which produces a measuring signal. Since the axle of running gear 2' supports the load of the car, its vertical movement senses not only the grade variations in the track but also the elastic deformation of the rails under the load. On the other hand, the sensing element 6' carries no load and, therefore, senses only the geometric position of the rails. The difference between parameter measured by the the running gear 2' and the sensing element 6", particularly when these values are fed into computers, establishes the condition of the track, i.e., whether the elastic deformation of the rails is within permissible limits or whether ballast tamping for added track support is needed.

As shown in detail in FIG. 4, the vertical position of each track rail 1 may be determined independently by mounting two pairs of the bell crank levers in association with a respective track rail, each pair of levers having its separate electric measuring signal generator 19, 20.

FIG. 5 schematically illustrates the inductance bridge which generates and transmits a signal responsive to the grade variations, as measured by the relative movements of the associated bell crank levers. The signal generator and transmitter comprises a cylindrical housing 19 of stainless steel wherein a differential reactivity with an axially movable armature 20 is mounted. Two measuring coils 25 are electrically connected to form half an inductance bridge connected to a carrier frequency amplifier 26, the bridge being completed by two precision resistances (not shown). The amplifier receives current from an electrical current supply circuit through an operating voltage stabilizer 27. When the armature 20 moves, the Wheatstone bridge is unbalanced and a measuring signal (current or voltage) is generated. This signal is proportional to the movement of the armature in respect of the housing. The signal is
amplified at 26 and, after being rectified, the measuring signal is transmitted to an indicator 12 and/or a signal recorder 13.

The general bell crank lever arrangement of FIG. 6 is the same as in FIG. 3 but, in this embodiment, the other or short arms of the levers are interconnected by flexible rod 29 which carries resistance strain gage means 28 to generate the measuring signal in a manner more fully described and claimed in our concurrently filed application Ser. No. 155,861, entitled “Mobile Track Survey Apparatus for Determining a Track Parameter.”

FIGS. 7 and 8 illustrate this embodiment in more detail. The flexible rod 29 is a tempered steel leaf spring having one end clamped to bell crank lever 21 and the other end pivotally connected to bell crank lever 14'. As shown in FIG. 6, one end of one arm of lever 14' is affixed to the axle 9a of sensing element 6' while its other end carries a bushing 34 pivotal on pivot pin 35 which is mounted on the chassis so that the lever arm will freely pivot in response to vertical movements of sensing axle 9a. A clamp is affixed to the bushing 34 and holds the one leaf spring end so that the leaf spring will be flexed in response to the pivotal movement of lever arm 14'. The free end of the leaf spring 29 carries a forked member 31 which is pivoted to the lug 32 by means of bearing 33 assuring the play-free transmission of the movement between member 31 and lug 32. The lug is affixed to the shorter arm of bell crank lever 21 which is pivoted on the chassis by pivot 22 whose pivotal axis extends transversely of the track parallel to the pivotal axis of pivot pin 35. The brackets 36 support the pivot pins on the chassis.

In the region of the greatest deformation or strain, i.e., adjacent the clamped end of leaf spring 29, pairs of resistance strain gage strips 28 are bonded to opposite faces of the leaf spring. The operation of the strain gage means is more fully described and claimed in concurrently filed application Ser. No. 155,861, entitled “Mobile Track Survey Apparatus for Determining a Track Parameter.”

FIG. 9 schematically illustrates the circuit diagram of a measuring signal generator and transmitter incorporating four strain gage strips 28 in a measuring bridge which receives current from a supply circuit through operating voltage stabilizer 37. The measuring signal is fed from the bridge to carrier frequency amplifier 38 which is also energized through stabilizer 37, and the amplified signal is rectified, further amplified and filtered, if desired, at 39 whence it is transmitted to the signal indicator instrument 12 and the signal recorder instrument 13 which makes a permanent record of the recorded signals. The measuring bridge is balanced to give a zero reading when the track has the desired evenness so that each deviation from the set bridge condition produces a corresponding signal.

We claim:
1. A mobile track survey apparatus for determining variations in the vertical position of the track, comprising
   1. a chassis mounted for mobility on the track rails for movement in the direction of elongation of the track;
   2. a load-carrying running gear resiliently supporting the chassis on the track;

3. a sensing element engaged with the track and mounted on the chassis for free vertical movement in respect thereto
   a. whereby the vertical movement of the sensing element corresponds to the vertical position of the track it engages;
   4. a pair of bell crank levers,
      a. each of the bell crank levers having two arms and the ratio of the lever arms being the same for both levers, and
      b. one arm of one of the bell crank levers being connected to the running gear and one arm of the other one of the bell crank levers being connected to the sensing element;
   5. means for mounting said bell crank levers on the chassis between the running gear and the sensing element for pivotal movement in a vertical plane extending in the track elongation;
   6. an electric measuring signal generator and transmitter mounted between, and connected to, the other arms of the bell crank levers for generating and transmitting an electric measuring signal proportional to any pivotal movement of the bell crank levers in said plane; and
   7. an indicator connected to the signal generator and transmitter for indicating the measuring signal.

2. The mobile track survey apparatus of claim 1, wherein the sensing element is a substantially load-free running gear having flanged wheels engaging the track rails.

3. The mobile track survey apparatus of claim 1, wherein the indicator includes a signal recorder.

4. The mobile track survey apparatus of claim 1, wherein said mounting means comprises a pair of pivots, the pivots mounting the levers on the chassis for pivoting about respective pivotal axes extending transversely to the track, and the pivots being vertically spaced from each other in a vertical plane defined by the pivotal axes.

5. The mobile track survey apparatus of claim 1, wherein the arms of each of the bell crank levers are of different lengths, a shorter one of the bell crank lever arms being the other arm connected to the electric measuring signal generator and transmitter.

6. The mobile track survey apparatus of claim 1, wherein each of the arms of the bell crank lever connected to the running gear is shorter than the corresponding arm of the bell crank lever connected to the sensing element.

7. The mobile track survey apparatus of claim 1, wherein the electric measuring signal generator and transmitter comprises an inductance bridge, a housing for the bridge being connected to the other arm of one of the bell crank levers, and an armature movable within said housing connected to the other arm of the other bell crank lever.

8. The mobile track survey apparatus of claim 7, wherein the electric measuring signal generator and transmitter comprises an electrical measuring bridge and an amplifier transmitting the electric measuring signal from the bridge to the indicator.

9. The mobile track survey apparatus of claim 1, comprising two of said pairs of bell crank levers each of said pairs connected with a separate one of the electric measuring signal generators, and each pair being associated with a respective one of the track rails for
independently determining the vertical position of each of said rails.

10. The mobile track survey apparatus of claim 1, wherein the sensing element is mounted underneath the chassis behind the running gear in the direction of movement of the apparatus in the track elongation direction.